

DERWENT-ACC-NO: 1981-48014D

DERWENT-WEEK: 198127

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TITLE: Thick-film diameter filaments - with  
regular diameter variation used in simulated for  
fabrics

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PRIORITY-DATA: 1979EP-0104797 (December 1, 1979)

PATENT-FAMILY:

PUB-NO	PAGES	PUB-DATE	
LANGUAGE		MAIN-IPC	
EP 30566 A		June 24, 1981	E
000	N/A		
DE 2967612 G		September 4, 1986	N/A
000	N/A		
EP 30566 B		July 30, 1986	E
000	N/A		

DESIGNATED-STATES: CH DE FR GB IT NL CH DE FR GB IT NL

CITED-DOCUMENTS: FR 2202959; GB 1141394 ; US 2418492 ; US  
2745136 ; US 3827932

APPLICATION-DATA:

PUB-NO	APPL-DATE	APPL-DESCRIPTOR	APPL-NO
EP 30566A		N/A	
1979EP-0104797		December 1, 1979	

INT-CL (IPC): D01D005/20, D03D027/00 , D04B001/04 ,  
D05C017/02

ABSTRACTED-PUB-NO: EP 30566A



#### BASIC-ABSTRACT:

Varying diameter filaments have thick-thin portions recurring at 5-500 mm intervals, a ratio of cross sectional areas of 4-50 between the portions, uniformly thick portions and uniformly thin portions along the filaments and an average fineness of 0.05-2000 den.

The filaments are made from polymer extruded through a 0.1-6 mm gap into a liq. bath, passed over a vibrating guide, drawn and set. The guide vibrates at 100-10,000 cps. at 1.5-2.5 mm amplitude with the filaments travelling at 1-1000 m per. min. The diameter variations along the filaments are in phase by at least 60%. The filaments can be crimped, non-circular, hollow or conjugated.

The regularity and high thick/thin ratio of the filaments render them useful in simulated fur pile fabrics.

ABSTRACTED-PUB-NO: EP 30566B

#### EQUIVALENT-ABSTRACTS:

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conjugated.

The regularity and high thick/thin ratio of the filaments render them useful in simulated fur pile fabrics.

TITLE-TERMS: THICK FILM DIAMETER FILAMENT REGULAR DIAMETER  
VARIATION SIMULATE  
FABRIC

DERWENT-CLASS: A94 F01

CPI-CODES: A12-S05A; A12-S05K; F01-E02; F04-B; F04-C;  
F04-D;

POLYMER-MULTIPUNCH-CODES-AND-KEY-SERIALS:

Key Serials: 0004 0016 0231 0374 0375 1283 1291 1294 1319  
1323 1462 1982 1986  
2368 2413 2414 2458 2475 2476 2480 2486 2489 2497 2525 2526  
2528 2529 2530 2531  
2628 2654 2819 2820 2821  
Multipunch Codes: 011 034 038 04- 072 074 076 141 143 144  
150 151 155 163 166  
169 170 171 173 252 253 256 30& 32& 33& 34& 369 415 428 429  
437 447 455 466 469  
481 483 484 485 486 551 560 566 575 596 664 665 667 688 726



(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets

(11) Publication number:

0 030 566

A1

(12)

## EUROPEAN PATENT APPLICATION

(21) Application number: 79104797.0

(51) Int. Cl.<sup>3</sup>: D 01 D 5/20  
 D 03 D 27/00, D 04 B 1/04  
 D 05 C 17/02

(22) Date of filing: 01.12.79

(43) Date of publication of application:  
 24.06.81 Bulletin 81/25

(84) Designated Contracting States:  
 CH DE FR GB IT NL

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(54) Thick-and-thin fibres, method to produce them and products therefrom.

(57) Disclosed are thick-and-thin filaments the fineness of which changes gradually and periodically along the longitudinal direction thereof, which are characterized by (a) a thick-and-thin recurring length of five to 500 millimeters, (b) a thick-and-thin ratio of four to 50, (c) an average fineness of 0.005 to 2000 deniers, and (d) almost constant cross section areas at both the thick and the thin portions, respectively. Also disclosed are thick-and-thin staple fibres made therefrom by cutting the thick-and thin filaments at predetermined intervals. Also disclosed are fabrics made of the thick-and-thin filaments or staple fibres as a component thereof. Disclosed is a method to produce the thick-and-thin filaments comprising (1) a step wherein molten fibre forming polymer is extruded through spinneret (9) holes at a constant throughput, (2) a step wherein the extruded filaments (22) run through a short gaseous gap (10) whose length is in the range of 0.1 to 6 millimeters before they plunge into liquid (11) for abrupt solidification by cooling, (3) a step wherein the solidified undrawn filaments are touched by at least one vibrating guide before being withdrawn at a constant speed, (4) a step wherein the undrawn filaments are drawn by roller systems (21,26) and (5) a step wherein the drawn filaments are thermally set by heaters (24,25).

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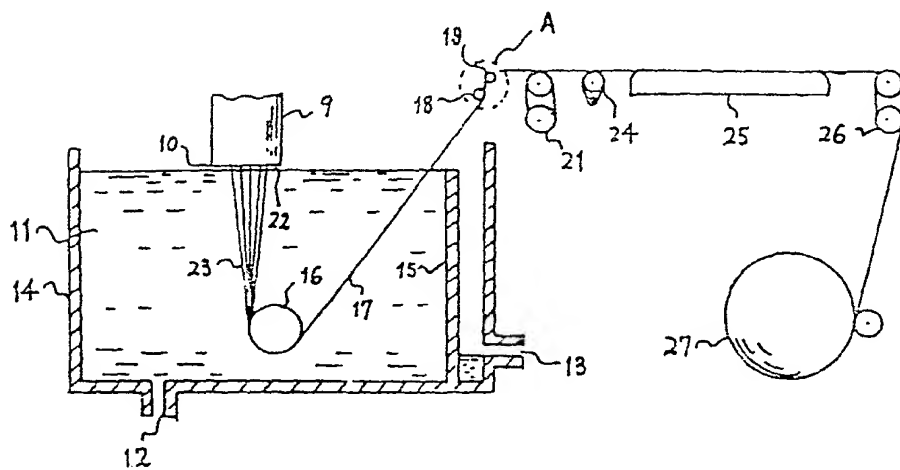


Figure 5

TITLE MODIFIED

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THICK-AND-THIN FIBERS AND PRODUCTS THEREFROM

5       The present invention relates to thick-and-thin fibers wherein the thick-and-thin ratio is high enough, the thick-and-thin recurring length is short and uniform, and the phases of the thick-and-thin profile among multi-filaments are practically identical.

10       The thick-and-thin fiber whose fineness varies along the longitudinal direction has been known. It is used, for example, in pile fabrics with an intention to simulate natural furs because the profile and the fiber properties of the thick-and-thin fiber are similar to the hair of the natural  
15 furs.

      The thick-and-thin fiber conventionally made of synthetic polymers, however, has so small thick-and-thin ratio of less than four that it was insufficient to be used to simulate the hair, for example, of the natural mink fur. Since it was  
20 difficult to produce the thick-and-thin multi-filaments or tow with a uniform length between the adjacent thick portions and a good phase coherency of the thick-and-thin profile among filaments, only dissimilar thick-and-thin staple fibers resulted when the thick-and-thin filaments or tow were cut by a constant  
25 fiber length. This was one of serious drawbacks against producing good simulated furs with excellent appearance and hand.

The Japanese Patent Publication No.52-47053, for example, describes a process for the thick-and-thin fibers wherein undrawn filaments are heated intermittently, and drawn at a constant speed for a predetermined length to stretch selectively the heated region with a result that a tapered thin portion is formed at the heated region, and then further drawn to be cut into the thick-and-thin staple fibers which are characterized by the following formulae:

$$l/D > 30, \text{ and } d = d' < 0.5D,$$

wherein

D is the fiber diameter at the thick portion,

d is the fiber diameter at the thin portion between the adjacent thick portions,

d' is the fiber diameter at a sharpened end, and

l is the length from the middle thin portion up to the sharpened end.

This process may be useful to render monofilament into thick-and-thin fiber with a relatively uniform thick-and-thin recurring length, but it seems to have a trouble in manipulating multi-filaments or tow because it is quite difficult to heat each filament at the same corresponding position. Therefore, good phase coherency of the thick-and-thin profile cannot be attained. In addition, since it becomes more difficult to draw the heated portion selectively as the fiber fineness increases, thick-and-thin fiber whose thick-and-thin ratio is

more than four becomes technically difficult.

A method of producing a filament having uniformly recurring symmetrically tapered portions has been disclosed in United States Patent 2,418,492, which comprises extruding  
5 an organic filament forming material in molten condition at constant volume rate through a spinneret across an air gap into a liquid cooling bath maintained at a temperature below the temperature of solidification of said material, and directly withdrawing the filament formed in accordance with a repetitive  
10 schedule of linear rates comprising a period of acceleration, a period of deceleration of greater duration than that of acceleration, and a period of uniform withdrawal. This method may enable us to produce thick-and-thin fibers with a good phase coherency of the thick-and-thin profile among filaments,  
15 but it is impossible to combine the extrusion process with the drawing process which is inevitable for the good end use because the non-uniform withdrawal which is intentionally applied persists all over the running filaments in the process.

It is well known that there are many methods to vary  
20 the fiber fineness along its longitudinal direction, including a periodical change in the throughput, take-up velocity or spinning length during the spinning process; or a periodical change in drawing ratio or length of the drawing zone during the drawing process; or an intermittent drawing to impart  
undrawn portions. Although these methods seem to be possible

in principle, they betray their incapability when it comes to making the thick-and-thin fibers with the high thick-and-thin ratio herein intended, and they cannot be used from the entrepreneur's point of view because of the difficulty in  
5 machinery.

The periodical change in the throughput can be, for example, attained by the use of the so-called pulsating pump or the method described in the Japanese Patent Publication No. 43-20246, wherein the constant metering has been coupled with  
10 a periodical change in the resident volume before the extrusion. This method cannot be used to produce the thick-and-thin fibers with high thick-and-thin ratio and short recurring length as intended in the present invention because too intricate machinery is required and also because the viscoelastic  
15 property of the polymer concerned damps the effect of the change in the resident volume.

Another method of varying the take-up velocity requires intricate machinery for the periodical change in the peripheral velocity of the rotating rollers. Some devices  
20 for this end can be found, for example, in the United States Patent 2,418,492 and the British Patent 1,1086,511. However, the change in the take-up velocity, as already pointed out, makes it difficult to combine the extrusion process with the drawing process which is inevitable for the good end use.  
25 The separation of the processes, therefore, becomes unavoidable,

which results in a deleterious effect on the phase coherency of the thick-and-thin profile among multi-filaments. To obtain the thick-and-thin fibers herein intended, the take-up velocity should be periodically altered from about zero to  
5 several tens or hundreds meters per minute, so that the rotating rollers have to swiftly change their rotating speed against their inertial force. This requirement may be temporarily realized in an experimental scale, but its permanent realization is so difficult that the industrial  
10 application of this method becomes impossible.

Another method of varying the spinning length in a melt spinning process consists of some manipulations by which the spinning length between the spinneret and the take-up device is altered. However, the spinning length in the melt  
15 spinning is usually so great that the thick-and-thin fibers with high thick-and-thin ratio and short thick-and-thin recurring length as intended in the present invention cannot be attained.

Another method adopted in drawing process is an imperfect drawing, wherein uniform undrawn filaments are drawn  
20 intentionally under a low drawing ratio so that some undrawn portions may be included. However, since there is a certain natural drawing ratio in which the imperfect drawing is realized, the thick-and-thin ratio is determined a priori  
25 and must remain at a low level. This is a fatal drawback

for the present purpose. On top of that, this method, wherein undrawn portions of filaments are intentionally included by the application of a certain low drawing ratio less than the natural drawing ratio, is very poor at giving thick-and-thin 5 fibers with a uniform thick-and-thin recurring length which is one of the important objects of the present invention. The vulnerability at the undrawn portions to a relatively small force or a chemical attack may also cause another problem in later processing.

10 As is apparent in the above explanation, the conventional miscellaneous method cannot afford the thick-and-thin fibers intended in the present invention, wherein the thick-and-thin ratio is high enough, the thick-and-thin recurring length is short and uniform, and the phase coherency of the thick-and- 15 thin profile among filaments is also good.

#### BRIEF SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide thick-and-thin multi-filaments which have a great 20 advantage in developing some new goods by the use of the thick-and-thin characteristic, wherein the thick-and-thin ratio is high enough, the thick-and-thin recurring length is short and uniform, and the phases of the thick-and-thin profile is practically identical among the multi-filaments. 25

Another object of the present invention is to provide

thick-and-thin staple fibers, wherein almost all the staple fibers have practically identical thick-and-thin profiles together with almost equal fiber length and average fiber fineness.

5           Still another object of the present invention is to provide various kinds of goods which utilize the characteristic shape of the thick-and-thin fibers, especially pile fabrics to simulate natural furs wherein the thick-and-thin fibers constitute the piles that stand close together with their  
10 thick portions floating over the ground fabric by means of the thin portions which are anchored on the ground fabric.

Further object of the present invention is to provide a process to produce the above-mentioned thick-and-thin fibers in an industrial scale with much benefit.

15           Still further objects of the present invention shall become apparent from the following explanation.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20           FIGURE 1 schematically shows a side view of the thick-and-thin fibers according to the present invention.

FIGURE 2 shows another example of the thick-and-thin fibers according to the present invention.

FIGURE 3(a) shows an example of the thick-and-thin staple fibers according to the present invention, and FIGURES  
25 3(b) to 3(h) show various examples of thick-and-thin staple

fibers that can be obtained from the thick-and-thin fibers according to the present invention.

FIGURE 4 illustrates a pile fabric in which the thick-and-thin fibers are used as a component of piles.

5       FIGURE 5 is a side sectional view of illustrative embodiment of the method for the present invention, and FIGURE 6 is the enlarged illustration of a part in FIGURE 5.

#### DETAILED DESCRIPTION OF THE INVENTION

10       The thick-and-thin fibers of the present invention can be characterized by the following items:

- (a) The thick-and-thin recurring length defined as a longitudinal length along the fiber axis between adjacent thick portions lies in the range of five to 500 millimeters.
- 15       (b) The thick-and-thin ratio defined as a ratio of the cross-sectioned area of the thick portion to that of the thin portion lies in the range of four to 50.
- (c) The cross-sectioned areas at the thick portions and those at the thin portions are almost constant, respectively.

20       Referring to FIGURE 1, the thick-and-thin filament 1 has thick portion 2 and thin portion 3 with a thick-and-thin recurring length 4 and the thick-and-thin ratio higher than four. It is characterized that the cross-sectioned area at the thick portion 2 and at the thin portion 3 are almost  
25       constant, respectively, and that when multi-filaments are

taken into account, all the phases of the thick-and-thin profile among the filaments are practically identical.

FIGURE 2 illustrates another example of the thick-and-thin fibers according to the present invention, in which the phases  
5 of the thick-and-thin profile among the multi-filaments do not necessarily coincide with each other.

When the area of the cross section of a thick-and-thin fiber is recorded along the fiber axis, a periodical change in the area can be seen. The ratio of the largest value of  
10 the area to the smallest value of it in an arbitrarily selected longitudinal domain that includes at least one thick and thin portions each is here called thick-and-thin ratio in the present invention. This thick-and-thin ratio can be considered as fiber fineness ratio at the corresponding thick  
15 and thin portions. When a circular cross section is considered, this thick-and-thin ratio should be principally equal to the square of the diameter ratio at the corresponding thick and thin portions. The thick-and-thin recurring length is the distance between adjacent thick portions measured in  
20 the longitudinal direction of the fiber.

In the following explanation, the coefficient of variation of the thick-and-thin recurring length is calculated from data measured on 50 samples arbitrarily selected according to the following formula:

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$$CV(\%) = \frac{\sqrt{\frac{1}{50} \sum_{i=1}^{50} l_i^2 - L^2}}{L} \times 100,$$

5 wherein  $l_i$  is the  $i$ -th value of the thick-and-thin recurring length in the 50 samples arbitrarily chosen, and  $L$  is an average value of the thick-and-thin recurring length of the above 50 samples.

The inphase value which shall indicate the phase  
10 coherency of the thick-and-thin profile among the multi-filaments is here defined by the following formula:

$$15 \quad G = \left( 1 - \frac{\sum_{i=1}^n \left| m_i - \frac{\sum_{j=1}^n m_j}{n} \right|}{n(L/2)} \right) \times 100,$$

wherein

$G$  is a notation for the inphase value,

20  $n$  is number of the filaments in the thick-and-thin filaments,

$m_i$  and  $m_j$  are the nearest distance of the thick portion from the standard position set out arbitrarily on the filaments with sign to designate the direction, and

$L$  is an average thick-and-thin recurring length as defined above.

25

If all the phases of the thick-and-thin profile among the

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multi-filaments coincide with each other, the inphase value G takes a value of 100. This value, of course, decreases as the phase coherency decreases.

The thick-and-thin fibers of the present invention have  
5 a special feature characterized by the thick-and-thin ratio of four to 50, the thick-and-thin recurring length of five to 500 millimeters, and the thick-and-thin inphase value of at least 60 percents. The higher is the thick-and-thin ratio, the better goods which reflect the excellent features of the  
10 thick-and-thin fibers result. If the thick-and-thin ratio is less than four, fabrics made of the mixed yarn, in which the thick-and-thin fibers are included, cannot exhibit any special characteristic attributable to the thick-and-thin fibers. On the other hand, if the thick-and-thin ratio is  
15 more than fifty, the difference of the fiber texture at the thick portion and thin portion becomes so large that the thick-and-thin fibers thus obtained are no longer useful for the fabrication. This thick-and-thin ratio can be arbitrarily chosen in the range of four to fifty according to the kind of  
20 fabrics or final goods and usage intended. It should be preferably selected in the range of four to 20 when used as multi-filaments, four to 40 when used as staple fibers, and four to 20 when used in pile fabrics for simulated furs.

The thick-and-thin recurring length should lie in the  
25 range of five to 500 millimeters, preferably five to 200 millimeters. The thick-and-thin recurring length less than five millimeters is very difficult to be realized in an

industrial sense. On the other hand, the thick-and-thin recurring length greater than 500 millimeters cannot show any characteristics attributable to the thick-and-thin fibers in the final goods, especially in pile fabrics.

5       The thick-and-thin filaments with a good phase coherency of the thick-and-thin profile as shown in FIGURE 1 can be converted into staple fibers with practically the same thick-and-thin profile and dimension as depicted in FIGURE 3 because it is easy to position the cutting place all at once in the  
10 filaments. FIGURE 3(a) illustrates the thick-and-thin staple fibers obtained by cutting the thick-and-thin filaments of good phase coherency at the thin portions on both sides of each thick portion. The thick-and-thin staple fibers thus obtained are practically of the same profile and dimension.  
15 FIGURES 3(b) to 3(g) show the other examples of the thick-and-thin staple fibers which can be obtained by cutting the thick-and-thin filaments of good phase coherency at a predetermined interval.

      In one embodiment of the present invention the  
20 inphase value of the thick-and-thin fibers should be at least 60 percents, preferably in the range of 70 to 98 percents. The thick-and-thin staple fibers according to the present invention can be preferably produced by cutting the thick-and-thin multi-filaments at a predetermined interval as explained  
25 above. If the thick-and-thin multi-filaments whose inphase

value is more than 60 percents are used to be cut into the staple fibers with a proper fiber length, good thick-and-thin staple fibers, at least 50 percents of which consist of practically the same thick-and-thin profile, result. This  
5 good thick-and-thin staple fibers can produce an excellent pile fabric which is characterized by good hand and touch and brilliancy.

If the phase coherency of the thick-and-thin profile among filaments is very poor and the inphase value is small,  
10 the thick-and-thin staple fibers obtained by cutting can only consist of various dissimilar thick-and-thin profiles. These can be used in another usage wherein such a various mixture of profiles is preferred. The thick-and-thin filaments with low inphase value may be especially suitable to make spun  
15 yarns by simultaneous cutting and spinning as is common in the art.

The thick-and-thin fibers of the present invention, whether they are continuous multi-filaments or staple fibers, can be used by themselves or as a mixed yarn with some conventional synthetic fibers, wool, cotton, and hemp. However,  
20 in the latter case wherein the mixed yarn is considered, the content of the thick-and-thin fibers should lie in the range of one to 80 weight percents, and preferably two to 70 weight percents, so that the characteristic feature of the thick-and-  
25 thin fibers, i.e., an excellent decorative effect and good

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hand, may be fully utilized.

When the thick-and-thin fibers are used as staple fibers, their proper fiber length and the average fineness are 2.5 to 250 millimeters and 0.05 to 2000 deniers respectively, depending on the kind of the final goods or usage intended. The preferable range of the fiber length and the average fineness are 20 to 150 millimeters and 0.05 to 500 deniers, respectively. Especially, in case of pile fabrics the thick-and-thin staple fibers with the fiber length of 2.5 to 250 millimeters and the average fineness of 0.5 to 500 deniers are desirable for the excellent hand and touch and the good processibility. For brushes heavier fineness of 10 to 2000 deniers is preferable. Although the thick-and-thin staple fibers have a spinnerbility without crimp, crimp can be added if desired. The number of the recurring thick portions in a thick-and-thin staple fiber may be in the range of one to 100 as depicted in FIGURE 3(h) wherein the suffix  $i$  is allowed to be any integer from one to 100. There cannot be found any additional advantages over the upper limit of 100 in the application of the thick-and-thin staple fibers.

When the thick-and-thin fibers are used as multi-filaments by themselves, there is no limit in the fiber fineness, wherein the regularity of the thick-and-thin profile, the high thick-and-thin ratio, and the short and uniform thick-and-thin recurring length give the final goods a characteristic appearance, brilliancy, and an excellent hand.

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In case of mixed filament yarn or mixed-twisted filament yarn with some conventional filaments, the content of the thick-and-thin fibers should be, as in the case of the staple fibers, in the range of one to 80 weight percents, and preferably two 5 to 70 weight percents.

The polymer which constitutes the thick-and-thin fibers of the present invention can be any already known fiber forming synthetic polymers such as polyesters, polyamides, polyacrylonitriles, and their copolymers. Especially polyesters and 10 poly(butylene terephthalate) if specified are the best selection among them.

The thick-and-thin fibers can be made not only of a single polymer above-mentioned, but also of at least two polymers in any form of a mixed style or a conjugated style 15 common in the art. They can also be hollow fibers. In addition, the thick-and-thin fibers can have properties of high shrinkage or latent crimpability which can be induced by some combination of polymers and a proper selection of the drawing and heating conditions, which is a quite common knowledge in 20 the art.

The conventional fibers which are used with the thick-and-thin fibers of the present invention can be any of the already known synthetic fibers made of polyesters, polyamides, polyacrylonitriles, and their copolymers, as well as the 25 natural fibers such as wool, cotton, and hemp. They may be

selected according to the performance expected in the final goods or by the usage, and should not be confined by the above list. The fiber length and its fineness of the conventional staple fibers should be in the range of one to 250 millimeters and 0.05 to 2000 deniers, respectively. In case of multi-filaments the fineness should be in the range of 0.05 to 2000 deniers.

The thick-and-thin fibers of the present invention can be converted into various kinds of knitted, woven or nonwoven fabrics which reflect the characteristics of the thick-and-thin fibers by means of the well known techniques such as weaving, knitting and the other miscellaneous procedures common in the art. Mixing with conventional regular fibers is preferable, wherein the thick-and-thin fibers should be exposed on or over the surface of the knitted, woven or nonwoven fabrics. Methods or machines to make such fabrics wherein the thick-and-thin fibers are exposed on or over the surface of the ground fabric can be exemplified by double velvet loom, sealskin fabric knitting machine, tufting machine, sliver knitting machine, needle punching machine, all is common in the art. Among the fabrics made of the thick-and-thin fibers together with regular fibers, pile fabrics wherein the thick-and-thin fibers of the present invention are used as the piles at least in a part with their thick portions floating over the ground fabric by means of thin portions anchored on

the surface of it well resemble natural furs in their appearance hand and structure.

A schematic example of pile fabrics to simulate natural furs is given in FIGURE 4, wherein 5 is the thick-and-thin fiber, 6 is conventional fiber of constant fineness, 7 is a ground fabric, and 8 is backing layer. When the thick-and-thin fibers are used as one of pile components and thier length is greater than the height of the other conventional fibers as depicted in FIGURE 4, the uppermost surface of the pile fabric is covered with the thick-and-thin fibers, producing a simulated fur with an excellent hand and appearance just like natural mink fur.

The thick-and-thin fibers with a high thick-and-thin ratio, a short and uniform thick-and-thin recurring length, and a good phase coherency of the thick-and-thin profile among multi-filaments can be industrially obtained by the method described below in detail. The thick-and-thin fibers of the present invention can now be produced by the following steps combined sequentially:

- (1) A step wherein molten fiber forming polymer is extruded through spinneret hole at a constant throughput,
- (2) A step wherein the extruded filament runs through a short gaseous gap whose length is less than six millimeters before it plunges into liquid for the solidification by cooling or coagulating,

(3) A step wherein the solidified undrawn filament is touched by at least one vibrating substance of any form before drawn at a constant speed by rotating roller system,

(4) A step wherein the undrawn filament is drawn by some rotating roller systems, and

(5) A step wherein the drawn filament is heat set if desired. In the above items and the following explanation single nouns for polymer, filament, and hole may be changed into plural ones and interpreted as such if desired.

0 The method of the present invention will be now explained in detail with reference to FIGURE 5. The filament 22 which is extruded in molten state through a hole in the spinneret 9 runs through a short gaseous gap 10 and thereafter plunges into liquid quenching bath 11 so that it may be abruptly cooled or coagulated and solidified. The liquid quenching bath 11 is provided with inlet 12 for the quenching liquid, and outlet 13 for the drain of the overflowed liquid from a dam 15 which has been installed to maintain the liquid level in the vessel 14. The running filament 15, submerged in the liquid bath 11, changes  
5 its running direction by means of guide 16, and again emerges into the air, and runs on guide 18 and vibrating guide 19, and then is withdrawn at a constant speed by the rotating roller system 21. The guide 18 and the vibrating guide 19 play an important role in providing a periodical change in the linear  
5 axial velocity of the running filament before the guide 19.

This periodical change in the filament speed is transferred to the extruded filament 22 just below the spinneret and above the surface of the liquid bath 11, which makes it possible to embody the thick-and-thin profile in the filament 23 owing to the mass conservation. The vibrating guide 19 should preferably move parallel to the running direction of the entering filament 20, but nonparallel movement of the guide 19 against the running direction may be applied if necessary. The guide 19 should be light enough to allow a swift periodical movement without fail. The vibrating motion of the guide 19 can be induced by any known procedures such as a mechanical system by cam and electromagnetic mechanism, which need not to be specified here. The filament that has passed the roller system 21 is next preheated on the warm roller system 24 as long as necessary, then runs in touch with a heated plate 25 if desired, and then wraps around the roller system 26 which rotates at a higher peripheral speed than the warm roller system 24, wherein the drawing of the extruded and solidified thick-and-thin filament is carried out, and finally the drawn thick-and-thin filament 27 is collected on a spool.

In the above explanation the melt extrusion of thermoplastic polymers has been assumed. However, in case of the solution spinning the quenching bath 11 in the above explanation should be, of course, a coagulating bath and interpreted as such. This kind of the transformation of the concept is a commonsense in the art.

The fiber forming synthetic polymers used in the present invention comprise polyesters such as poly(ethylene-terephthalate) and poly(butylene-terephthalate), polyamides such as polycaprolactam and poly(hexamethyleneadipamide),  
5 polyacrylonitriles and their copolymers. The extrusion of the filaments can be carried out by the use of the conventionally known spinning machinery.

The shape of the spinneret hole may be circular or noncircular, depending on the final use of the thick-and-  
10 thin fibers. In case of the noncircular cross section the final shape of the cross section of the thick-and-thin fibers is almost the same as that of the spinneret hole, which is quite a characteristic feature of the present process since in the conventional melt spinning the shape  
15 of the final noncircular cross section is considerably distorted in comparison with that of the original spinneret hole. The way to cope with such a difference, however, may be a common knowledge in the art. The area of the cross section of the spinneret hole should be as small as possible  
20 so far as allowed since the realization of the high thick-and-thin ratio becomes easier as the area of the cross section of the spinneret hole decreases.

The existence and its distance of the gaseous gap between the spinneret and the quenching or coagulating  
25 liquid bath is indispensable in the present invention, and the distance should be less than six millimeters. The reason is that high thick-and-thin ratio as specified in the present

invention can be accomplished only by the application of such a short gaseous gap, and that if this distance is increased beyond the above limit, a deleterious phenomenon of so-called draw resonance takes place, resulting in difficulty for the stable manufacturing of the thick-and-thin fibers. The lower limit of the distance of the gaseous gap can be allowed as small as possible in an industrial sense. However, a distance from one to three millimeters is preferable. If the remaining conditions are fixed, the thick-and-thin ratio increases as the distance of the gaseous gap decreases. The distance of the gaseous gap, therefore, can be adjusted by the desired value of the thick-and-thin ratio. The gas in the gaseous gap may be preferably air, but the other gas such as nitrogen, argon can be used if necessary so long as it does not abruptly cool down the extruded molten filaments.

In the melt spinning the liquid of the quenching bath may be any substance so long as its boiling point is less than the glass transition temperature of the polymer concerned. Of course, water should be the first choice. The temperature of the quenching liquid bath should be less than the glass transition temperature of the polymer concerned. It is allowed that the temperature of the liquid is locally above the glass transition temperature of the polymer concerned. The filaments abruptly cool down to less than the glass transition temperature as soon as they plunge into the quenching liquid bath,

and then convert their running direction at a stationary or rotating guide, and finally emerge from the quenching liquid bath.

The amplitude and the frequency of the vibrating guide  
5 can be determined by the required values of the thick-and-thin ratio and the thick-and-thin recurring length. As depicted in FIGURE 6, a touch with a guide 18 to secure the direction of the running filaments before the touch with the vibrating guide 19 is preferable.

10 The roller systems for the withdrawal of the filaments at a constant speed and for the drawing process may be provided in a conventional form as common in the art. It is preferable that heated rollers are used supplementarily for the stable performance of the drawing. The multi-stages drawing wherein  
15 the drawing process is carried out in more than two stages can be also considered. The drawing process should be carried out so that the thick-and-thin ratio of the drawn filament is always larger than that of the undrawn filament. This is a fundamental requirement of the stable production of the thick-  
20 and-thin fibers in the present invention. Therefore, the thick-and-thin ratio and the thick-and-thin recurring length of the undrawn filaments should be beforehand designed according to this requirement. Heat setting with or without some relaxation is also taken into account. To this end any methods  
25 that are useful and well known in the art can be applied.

The thick-and-thin fibers according to the present invention can provide a unique effect in appearance and hand of fabrics therefrom if they are used as a component. They are useful not only for pile fabrics to simulate natural furs 5 but also for fabrics with the other special effects such as dry touch or moire pattern on account of the coexistence of different portions of various finenesses and twist.

The thick-and-thin fibers can be easily converted into staple fibers with either or both ends cut at the thin portions 10 by virtue of their excellent phase coherency of the thick-and-thin profile among the multi-filaments. Further sharpening of the thin end by mechanical or chemical method can be carried out if desired. They can be preferably suitable to a component of simulated furs and brushes.

15 Although the present invention is good at affording the thick-and-thin fibers with excellent phase coherency of the thick-and-thin profile among filaments, randomization of this thick-and-thin profile among the filaments is also easy and can be applied if desired. Such thick-and-thin fibers may be 20 preferably used, for example, in a process such as spinning by the simultaneous cutting.

For the purpose of illustration only, this invention will now be illustrated by the following examples. Of course, this invention should not be limited to the following examples.

Example 1

From a spinneret with 48 holes each of 0.4 millimeter in diameter poly(butylene terephthalate) was melt-spun at 260°C by the total throughput of 7.2 grams per 5 minute. The extruded filaments ran through 1.5 millimeters of the air gap and thereafter plunged into the liquid quenching bath maintained at about 0°C, where they were submerged for as long as 50 centimeters. They were then touched by a vibrating guide which vibrated in the same direction of the 10 running filaments with the amplitude of 1.5 millimeters and the frequency of 1200 cycles per minute, and thereafter withdrawn at the speed of 11.4 meters per minute by the rotating roller system on which the filaments were wrapped around three times. The filaments were then preheated by running 15 around five times on the roller system whose diameter was 100 millimeters and whose temperature was controlled at 50°C, and then drawn by the roller system which rotated at the peripheral speed of 34.2 meters per minute.

The thick-and-thin fibers thus obtained had the 20 thick-and-thin ratio of 9:1, the thick-and-thin recurring length of 34 millimeters, the coefficient of variation of the thick-and-thin recurring length of 1.0 percent, and the inphase value of the thick-and-thin profile among the filaments of 86 percents.

25 The thick-and-thin fibers were cut into staple fibers by cutting selectively at the thin portion with a cut length of 68 millimeters which corresponded to twice the thick-and-thin recurring length. About eighty percents of

the staple fibers thus obtained took practically the same profile with both of the thin ends and a thin portion in the middle of the staple fibers, as depicted in FIGURE 3(g).

5

Example 2

From a spinneret with 96 rectangular holes each of 0.12 millimeter width and 0.36 millimeter length poly-(ethyleneterephthalate) was melt-spun at 290°C by the total throughput of 34.6 grams per minute. The extruded  
10 filaments ran through the air gap of 2.0 millimeters and thereafter plunged into liquid quenching bath maintained around 25°C, where they were submerged for as long as 75 centimeters. They were then touched by a vibrating substance which vibrated in the same direction of the running.  
15 filaments with the amplitude of 2.5 millimeters and the frequency of 2400 cycles per minute, and thereafter withdrawn at the speed of 38.4 meters per minute by a rotating roller system on which the filaments were wrapped around four times. The filaments were then preheated by running around eight  
20 times on the roller system whose diameter was 130 millimeters and whose temperature was controlled at 100°C, and then drawn by the roller system which rotated at the speed of 127 meters per minute, and then heat set under 5 percents relaxation in touch with heating plate of two meters in length  
25 and maintained at 220°C.

The thick-and-thin fibers thus obtained had the thick-and-thin ratio of 7:1, the thick-and-thin recurring

length of 53 millimeters, the coefficient of variation of the thick-and-thin recurring length of 1.5 percents and the inphase value of the thick-and-thin profile among filaments of 92 percents.

5           The thick-and-thin fibers were then cut into staple fibers by cutting selectively at the thin portion with a cut length of 106 millimeters corresponding to twice the thick-and-thin recurring length. About eighty percents of the staple fibers thus obtained took practically the same pro-  
10 file with both of the thin ends and a thin portion in the middle of the staple fibers as depicted in FIGURE 3(g).

### Example 3

From a spinneret with 36 holes each of 0.4 milli-  
15 meter in diameter poly(butylene terephthalate) was melt-spun at 270°C by the total throughput of 3.5 grams per minute. The extruded filaments ran through the air gap of 1.5 millimeters and thereafter plunged into the liquid quenching bath maintained at about 10°C, where they were submerged for  
20 as long as 50 centimeters. They were, then, touched by a vibrating bar which vibrated in the same direction of the running filaments with the amplitude of 1.5 millimeters and the frequency of 1200 cycles per minute, and thereafter withdrawn at the peripheral speed of 9.5 meters per minute.

25           The thick-and-thin filaments thus obtained up to this stage had the thick-and-thin ratio of 5:1, and thick-and-thin recurring length of 8 millimeters. They must be,

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however, additionally drawn because the as-spun thick-and-thin filaments had too large extensibility at break to be used for the end use. The drawing, therefore, carried out by hot roller system with the drawing ratio of 3.1:1 followed by nonrelaxing heat-set of 180°C and 1.3 second. The drawing performance was very good without any breakage of filaments. The drawn thick-and-thin fibers thus obtained had the thick-and-thin ratio of 9:1 and the thick-and-thin recurring length of 25 millimeters together with low variation in the ratio and the recurring length among the filaments. The birefringences at the thin portion and the thick portion were 0.150 and 0.040, respectively.

#### Comparative example 1

15 In the previous example 3 the drawing ratio was increased so that the thick-and-thin ratio of the drawn filaments may be equal to that of the undrawn filaments. The result is summarized in Table I, which indicates that the breakage of the filaments took place and the stable drawing cannot be accomplished under the ultimate condition to realize the equal thick-and-thin ratio both at the undrawn stage and at the drawn stage.

25

Table I Processibility on Drawing

Drawing Ratio	Thick-and-Thin Ratio of Drawn Filaments	Processibility at the Drawing
	Thick-and-Thin Ratio of Undrawn Filaments	
5		
3.1	1.8	Good
4.5	1.2	Not so good
5.5	1.0	Very bad

10      Example 4

The thick-and-thin filaments obtained in the previous example 2 were cut into staple fibers by cutting selectively at the thin portion with a cut length of 53 millimeters. The staple fiber thus obtained had the fiber length of 53 millimeters and the average fiber fineness of 27 deniers, and took a shape with thin portion in both ends and thick portion in the middle of the staple fiber as depicted in FIGURE 3(b).

The thick-and-thin staple fibers thus obtained were used with conventional staple fibers to make a mixed yarn of 16's count and 400 twists per meter. The composition of the mixed yarn is as follows:

- (1) The thick-and-thin staple fibers of the present invention  
27 deniers - 53 millimeters ..... 10 weight percents
- 25 (2) The conventional acrylic staple fibers  
3 deniers - 51 millimeters ..... 55 weight percents
- (3) The conventional nylon staple fibers  
1.5 deniers - 51 millimeters ..... 35 weight percents

The two ply yarn of the above mixed yarns was knitted by the weft knitting machine. The knitted fabric was then treated slightly by a gig mill, to bring about a new knitted fabric with excellent taste and appearance of fabric containing natural hairs.

#### Example 5

The thick-and-thin staple fibers obtained in the example 4 were used with the following other conventional staple fibers to make a mixed yarn of 20's count by a conventional woolen spinning machine. The composition of the mixed yarn is as follows:

- (1) The thick-and-thin staple fibers of the present invention  
27 deniers - 53 millimeters ..... 50 weight percents
- 15 (2) The conventional polyester staple fibers  
1 denier - 51 millimeters ..... 50 weight percents

Using this mixed yarn as weft and the conventional false-twist texturized polyester yarn of 150 deniers and 48 filaments as warp, plain woven fabric was made. Additional treatment of the fabric by a gig mill brought about new woven fabric with an excellent taste and appearance of fabric containing natural hairs.

#### Comparative example 2

25 From a spinneret with 160 holes each of 0.45 millimeter in diameter poly(ethyleneterephthalate) was melt-spun at 290°C by the total throughput of 68 grams per minute. The extruded filaments ran through the air gap of 15 millimeters

and plunged into the liquid quenching bath maintained at about 10°C, where they were submerged for as long as 100 centimeters. They were, then, touched by a vibrating bar which vibrated in the same direction of the running filaments with the amplitude of 8 millimeters and the frequency of 900 cycles per minute, and thereafter withdrawn at the speed of 47 meters per minute. The undrawn thick-and-thin filaments were then drawn three times to provide the thick-and-thin filaments with the thick-and-thin ratio of 2:1 and the thick-and-thin recurring length of 157 millimeters.

The thick-and-thin filaments thus obtained were cut into staple fibers of average fiber fineness of 27 deniers by cutting selectively at the thin portion with a cut length of 157 millimeters. Since these thick-and-thin staple fibers had longer thick-and-thin recurring length and smaller thick-and-thin ratio than those in the example 5, they were difficult to be spun unless additional crimp was incorporated.

#### Example 5

From a spinneret with 160 rectangular holes each of width 0.14 millimeters and length 0.32 millimeters poly (butyleneterephthalate) was melt-spun at 270°C by the total throughput of 15.7 grams per minute, and then processed just as in the example 3 to give the thick-and-thin filaments with the thick-and-thin ratio of 9:1, the thick-and-thin recurring length of 25 millimeters and the inphase value of the thick-and-thin profile among the filaments of 90 percents.

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They were then cut into staple fibers by cutting selectively at the thin portion with a cut length of 50 millimeters corresponding to twice the thick-and-thin recurring length.

The thick-and-thin staple fibers thus obtained  
5 were used with conventional acrylic staple fibers of high shrinkage at boiling to make a sliver whose composition is as follows:

- (1) The thick-and-thin staple fibers of the present invention  
30 deniers - 50 millimeters ..... 50 weight percents  
10 The fineness at the thick portion is 90 deniers  
The fineness at the thin portion is 10 deniers
- (2) The conventional acrylic staple fibers of 22 percents shrinkage at boiling  
3 deniers - 38 millimeters ..... 50 weight percents  
15 The sliver was fed to the sliver knitting machine to make pile fabric using acrylic spun yarn of 30's count as ground yarn. The pile fabric then underwent backing by acrylic resin, heat setting and finally polishing to give a simulated fur with an excellent hand and appearance.

20

#### Comparative example 3

In the process to make the thick-and-thin filaments just described in the previous example 6, only the distance of the air gap was changed from 1.5 to 3 millimeters. The  
25 thick-and-thin filaments thus obtained had the low thick-and-thin ratio of 3:1, the thick-and-thin recurring length of 15 millimeters, and the inphase value of the thick-and-thin profile among the filaments of 90 percents.

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The thick-and-thin filaments were converted to staple fibers and used to make a pile fabric by the same procedure as described in the previous example 6. The resultant pile fabric had only inferior character in its hand and appearance to that obtained in the example 6, indicating that the low thick-and-thin ratio could not exhibit the thick-and-thin characteristic.

#### Example 7

Four kinds of the thick-and-thin fibers which differed from each other only in their fineness were made, and then used to make pile fabrics as in the example 6. The properties of the resultant pile fabrics is given in Table II, which indicates that there is a proper fineness in simulating natural furs.

Table II Estimation on Fabrics

Average Fineness of Thick-and-Thin Fibers	Hand	Appearance
5 deniers	Soft	Good
30 deniers	Soft	Excellent
200 deniers	A little hard	Good
510 deniers	Hard	Bad

#### Comparative example 4

By a proper manipulation at guides in the example 6, randomization in the filament running length among the

filaments gave thick-and-thin fibers of low inphase value of 30 percents which meant that the phases of the thick-and-thin profile did not well coincide with each other among the filaments. The thick-and-thin ratio and the recurring  
5 length were 3:1 and 25 millimeters, respectively. The staple fibers which were made by cutting the thick-and-thin filaments with a cut length of 50 millimeters consisted of various kind of staple fibers whose shapes were quite random.

A pile fabric made of these staple fibers by the  
10 sliver knitting machine as in the example 6 had only inferior hand and appearance for the simulated fur.

#### Example 3

From a spinneret with five rectangular holes each  
15 of 0.14 millimeters width and 0.32 millimeters length poly (butyleneterephthalate) was melt-spun at 270°C by the total throughput of 0.5 grams per minute, and then processed just as in the example 3 to give the thick-and-thin filaments with the thick-and-thin ratio of 9:1, the thick-and-thin recurring  
20 length of 25 millimeters, the inphase value of 90 percents, and the average fiber fineness of 30 deniers.

The thick-and-thin filaments thus obtained were converted to a ply yarn with a high shrinkage polyester filaments of 35 percents shrinkage at boiling and the total fineness of 75 deniers with 72 filaments.

The yarn was used as pile yarn in the double warp loom with two ply polyester spun yarn of 30's as ground yarn.

In this looming the pile yarn was woven in such a way that the thin portion of the pile yarn, which corresponded to the thin portion of the thick-and-thin filaments included, was always situated so that the thin portion may protrude  
5 from the ground fabrics and one thin portion may be sandwiched between the two thick portions and be cut at this thin portion by knife. The resultant pile fabrics were then heated to bring about pile fabrics with two kinds of pile length by virtue of the highly shrinking of one of component  
10 fibers in the pile yarn. The pile fabrics were further finished with lubricant oil and polished. The final pile fabrics took an excellent appearance and hand just like the natural mink fur.

15        Example 9

The thick-and-thin filaments obtained in the previous example 8 were converted into a mixed twisted yarn with high shrinkage polyester filaments of 40 percents shrinkage at the boiling, whose total fineness was 150 deniers  
20 with 148 filaments. The yarn was tufted on a nonwoven fabric so that the thin portion of the yarn, which corresponded to the thin portion of the thick-and-thin filaments included, may be situated both on the ground nonwoven fabric and over it with a thick portion between them, and the thin portion  
25 floating above the thick portion over the ground fabric was cut by knife.

The resultant pile fabric then underwent heat

treatment to bring about two kinds of pile of different pile length, and thereafter was immersed in alkali solution so that the free end of the piles may be sharpened. The back side of the pile fabric was finished by polyurethane resin to fix the piles on the ground nonwoven fabric, and then the general finishing with lubricant and the polishing were carried out. The final pile fabric consisted of two kinds of piles, whose length from the surface of ground fabric were 23 millimeters and 14 millimeters in average, and their densities were about 500 fibers per square centimeter and about 15000 fibers per square centimeter, respectively. This pile fabric took an excellent appearance and hand and flexibility just like the natural mink fur.

15                    Comparative example 5

By a proper manipulation at guides in the example 8, thick-and-thin filaments of low inphase value of 30 percents were produced by randomization in the filament running length among the filaments. A mixed yarn was made with the above thick-and-thin filaments and the high shrinkage polyester filaments used in the example 9. The yarn was tufted as in the example 9, but in this case the selective positioning of the thin portion could not be accomplished because of the bad coherency of the thick-and-thin profile among the filaments. The final pile fabric had various piles of different shapes, and took an inferior appearance and hand to the corresponding one in the previous example.

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Example 10

From a spinneret with 10 rectangular holes each of 0.14 millimeters width and 0.32 millimeters length poly (butyleneterephthalate) was melt-spun at 270°C by the  
5 total throughput of 0.5 gram per minute, and then processed just as in the example 3 to give the thick-and-thin 10 filaments of 150 deniers with the thick-and-thin ratio of 9:1, the thick-and-thin recurring length of 25 millimeters, the inphase value of 90 percents, and the average fiber  
10 fineness of 15 deniers.

Using the thick-and-thin filaments as weft yarn and conventional polyester textured yarn of 150 total deniers and 48 filaments as warp yarn, twelve-harness weft sateen fabric was woven. The resultant fabric had the thick-and-  
15 thin filaments on the surface, and exhibited a unique and beautiful brightness and hand.

Next, the raising of weft yarn by cutting the thin portion by a gig mill and the following buffing brought about a new pile fabric with an excellent hand as if natural hairs  
20 had been mixed in.

While the principles of the invention have been illustrated and described in detail, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

25

What is claimed:

1. Thick-and-thin fiber wherein the fineness thereof changes gradually and periodically along the longitudinal direction thereof, and is characterized by the following  
5 items (a), (b), (c), and (d):
  - (a) The thick-and-thin recurring length, defined as a longitudinal length along the fiber axis between adjacent thick portions, lies in the range of five to 500 millimeters.
  - (b) The thick-and-thin ratio, defined as a ratio of the  
10 cross-sectioned area of the thick portion to that of the adjacent thin portion, lies in the range of four to 50.
  - (c) The cross-sectioned area at the thick portions and those at the thin portions are almost the same, respectively.
  - (d) The average fineness of the thick-and-thin fiber lies  
15 in the range of 0.05 to 2000 deniers.

2. Thick-and-thin fiber according to claim 1, wherein the thick-and-thin recurring length defined in the item (a) lies in the range of five to 200 millimeters, and the thick-  
20 and-thin ratio defined in the item (b) lies in the range of four to 20.

3. Thick-and-thin fibers according to claim 1, wherein they comprise plural thick-and-thin filaments whose inphase  
25 value is at least 60 percents. Here, the inphase value which shall indicate the phase coherency of the thick-and-thin profile among the filaments is defined by the following formula:

$$G = \left( 1 - \frac{\sum_{i=1}^n \left| m_i - \frac{\sum_{j=1}^n m_j}{n} \right|}{n(L/2)} \right) \times 100,$$

5 wherein

G is a notation for the inphase value,

n is number of the filaments in the thick-and-thin fibers,

$m_i$  and  $m_j$  are the nearest distance the thick portion from the standard position set out arbitrarily on the filaments

10 with sign to designate the direction, and

L is an average thick-and-thin recurring length.

4. Thick-and-thin fibers according to claim 3, wherein the inphase value lies in the range of 70 to 98 percents.

15

5. Thick-and-thin fiber or fibers according to claim 1, wherein they are staple fiber or fibers having at least one thick portion and one thin portion, respectively.

20

6. Thick-and-thin staple fibers according to claim 5, wherein the average fineness of the fiber lies in the range of 0.05 to 2000 deniers, and the fiber length thereof lies in the range of 2.5 to 250 millimeters.

25

7. Thick-and-thin staple fibers according to claim 5, wherein the average fineness of the fiber lies in the range

of 0.05 to 500 deniers, and its length lies in the range of 25 to 150 millimeters.

8. Thick-and-thin staple fibers according to claim 5,  
5 wherein more than fifty weight percents of fibers consist of the thick-and-thin fibers with almost the same thick-and-thin profile.

9. Thick-and-thin staple fibers according to claim 5,  
10 wherein the staple fibers in an amount of 70 to 98 weight percents consist of almost the same thick-and-thin profile.

10. Thick-and-thin staple fibers according to claim 5,  
wherein the staple fibers have crimp.

15

11. Thick-and-thin fibers according to claim 1, wherein the cross section thereof is of a shape comprising circle, ellipse, and non-circle.

20 12. Thick-and-thin fiber according to claim 1, wherein it has void or hollow in itself.

13. Thick-and-thin fiber according to claim 1, wherein it consists of at least two fiber forming synthetic polymers.

25

14. Thick-and-thin fiber according to claim 13, wherein it comprises a conjugated fiber made of at least two fiber forming polymers.

5 15. Thick-and-thin fiber according to claim 1, wherein it is made of at least one fiber forming synthetic polymer which comprises polyesters, polyamides, polyacrylonitriles, and their copolymers.

10 16. Thick-and-thin fiber according to claim 1, wherein it is made of either poly(ethyleneterephthalate) or poly(butylene terephthalate).

17. A yarn which comprises thick-and-thin fibers  
15 whose fineness along the longitudinal direction varies gradually and periodically and are characterized by the following items (a), (b), (c), and (d):

(a) The thick-and-thin recurring length, defined as a longitudinal length along the fiber axis between adjacent thick  
20 portions, lies in the range of five to 500 millimeters.

(b) The thick-and-thin ratio, defined as a ratio of the cross-sectioned area of the thick portion to that of the adjacent thin portion, lies in the range of four to 50.

(c) The cross-sectioned area at the thick portions and those  
25 at the thin portions are almost the same, respectively.

(d) The average fineness of the thick-and-thin fiber lies in the range of 0.05 to 2000 deniers.

18. A mixed yarn according to claim 17, wherein it comprises one to 80 percents of the thick-and-thin fibers and 99 to 20 percents of conventional fibers.

5 19. A mixed yarn according to claim 18, wherein the thick-and-thin fibers are multi-filaments with an average filament fineness of 0.05 to 500 deniers, and the conventional fibers are multi-filaments with an average filament fineness of the same range.

10

20. A mixed yarn according to claim 18, wherein the thick-and-thin fibers are staple fibers with an average fiber fineness in the range of 0.05 to 500 deniers, and the fiber length in the range of 25 to 150 millimeters; and the regular  
15 conventional fibers are staple fibers with an average fiber fineness and length of the same range, respectively.

21. A mixed yarn according to claim 18, wherein the thick-and-thin fibers are made of one of polymers comprising  
20 polyesters, polyamides, polyacrylonitriles, and their copolymers and the regular conventional fibers are natural fibers such as wool, cotton and hemp, or synthetic fibers which are made of at least one of polymers comprising polyesters, polyamides, polyacrylonitriles, and their copolymers.

25

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22. Fabric wherein its surface is at least partly covered with the thick-and-thin fibers whose fineness along the longitudinal direction varies gradually and periodically and are characterized by the following items (a), (b), (c), and (d):

5 (a) The thick-and-thin recurring length, defined as a longitudinal length along the fiber axis between adjacent thick portions, lies in the range of five to 500 millimeters.

(b) The thick-and-thin ratio, defined as a ratio of the cross-sectioned area of the thick portion to that of the  
10 adjacent thin portion, lies in the range of four to 50.

(c) The cross-sectioned area at the thick portions and those at the thin portions are almost the same, respectively.

(d) The average fineness of the thick-and-thin fiber lies in the range of 0.05 to 2000 deniers.

15

23. Fabric according to claim 22, wherein it is a pile fabric, and the piles thereof consist of at least two kinds of fibers, one of which shall be the thick-and-thin fibers.

20 24. Pile fabric according to claim 23, wherein the fiber length of the thick-and-thin fibers which constitute the piles is at least 25 percents longer than that of the other pile fibers.

25

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25. Pile fabric according to claim 23, wherein the thick-and-thin fibers are in average at least 25 percents higher than the other piles.

5        26. Pile fabric according to claim 23, wherein the pile comprises thick-and-thin fibers and one kind of conventional fibers selected from polyester fibers, polyamide fibers, polyacrylonitrile fibers, cotton, wool, hemp, and mixed fibers thereof.

10

27. Pile fabric according to claim 23, wherein the piles comprise 10 to 90 weight percents of thick-and-thin fibers with their fiber length of 2.5 to 250 millimeters and their average fiber fineness of 0.05 to 2000 deniers, and 90 to 15 10 weight percents of conventional fibers selected from polyester fibers, polyamide fibers, polyacrylonitrile fibers, cotton, wool, and hemp whose fiber length lies in the range of one to 250 millimeters and their average fiber fineness lies in the range of 0.05 to 2000 deniers.

20

28. Pile fabric according to claim 23, wherein the thick portion of the each thick-and-thin fiber is not anchored on the ground fabric, but floats over it by means of the thin portion which is anchored on the ground fabric.

25

29. Pile fabric according to claim 28, wherein the free end of the each pile consists of the thin portion of the thick-and-thin fibers.

5 30. Pile fabric according to claim 23, wherein the pile density of the thick-and-thin fibers lies in the range of 0.5 to 1000,000 fibers per square centimeter, and that of the remaining fibers which are selected from polyester fibers, polyamide fibers, polyacrylonitrile fibers, cotton, wool, and  
10 hemp lies in the range of 0.1 to 100,000,000 fibers per square centimeter.

31. A method to produce the thick-and-thin fibers which comprises the following steps:

- 15 (1) A step wherein molten fiber forming polymer is extruded through spinneret holes at a constant throughput,  
(2) A step wherein the extruded filaments run through a short gaseous gap whose length lies in the range of 0.1 to 6 millimeters just before they plunge into liquid for solidification  
20 or coagulation,  
(3) A step wherein the solidified or coagulated undrawn filaments are touched by at least one vibrating substance before withdrawn at a constant speed by some roller systems,  
(4) A step wherein the undrawn filaments are further drawn  
25 by some roller systems, and  
(5) A step wherein the drawn filaments are thermally set if desired.

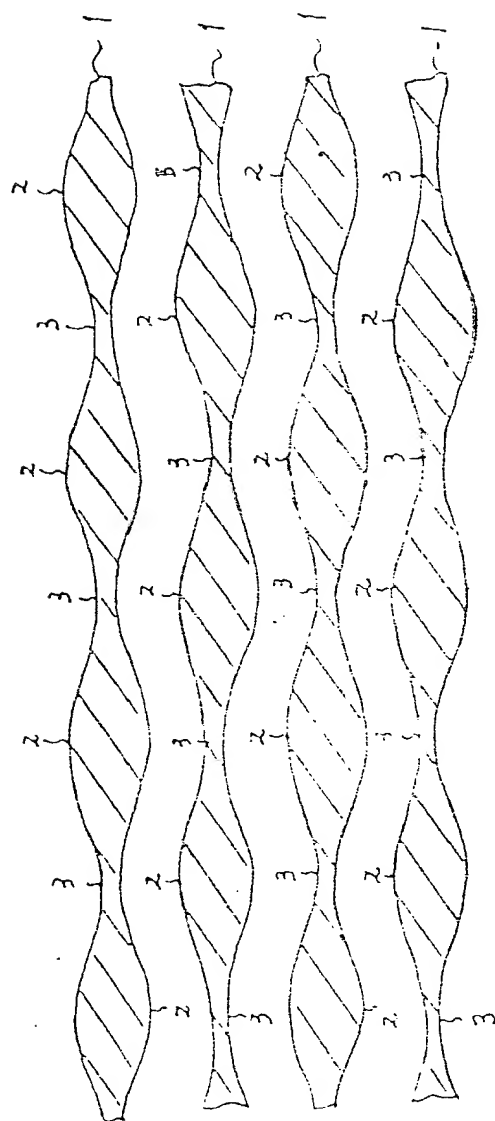
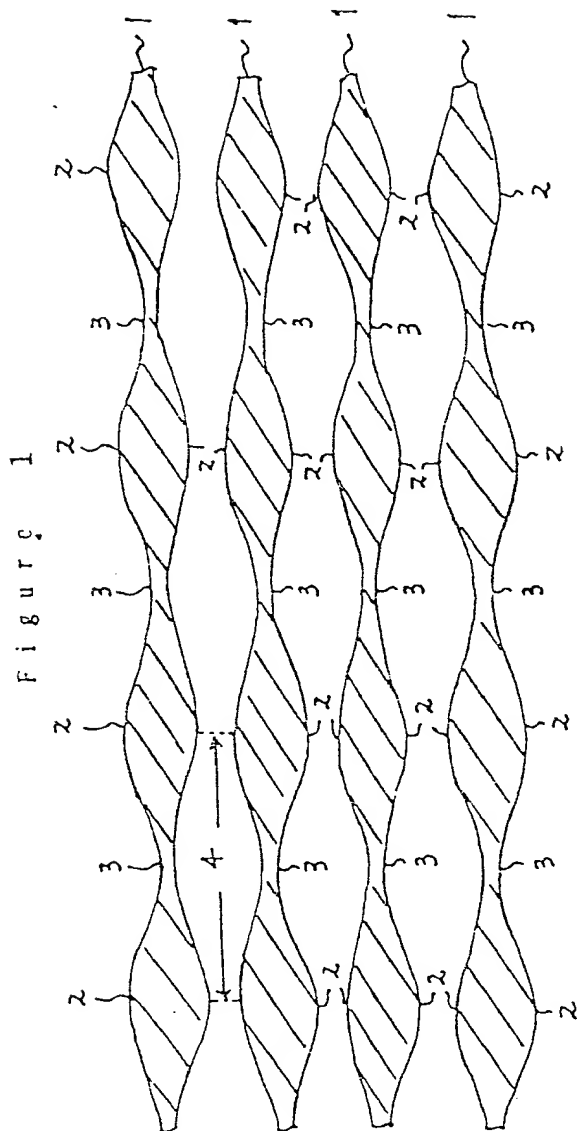
32. A method according to claim 31, wherein the liquid temperature in the second step is less than the glass transition temperature of the polymer concerned.

5        33. A method according to claim 31, wherein the vibrating frequency of the vibrating substance in the third step lies in the range of 100 to 10,000 cycles per minute.

34. A method according to claim 31, wherein the take-up  
10 velocity of the filaments in the fourth step lies in the range of one to 1000 meters per minute, and the final filaments' speed in the drawing process lies in the range of 1.5 to 6000 meters per minute.

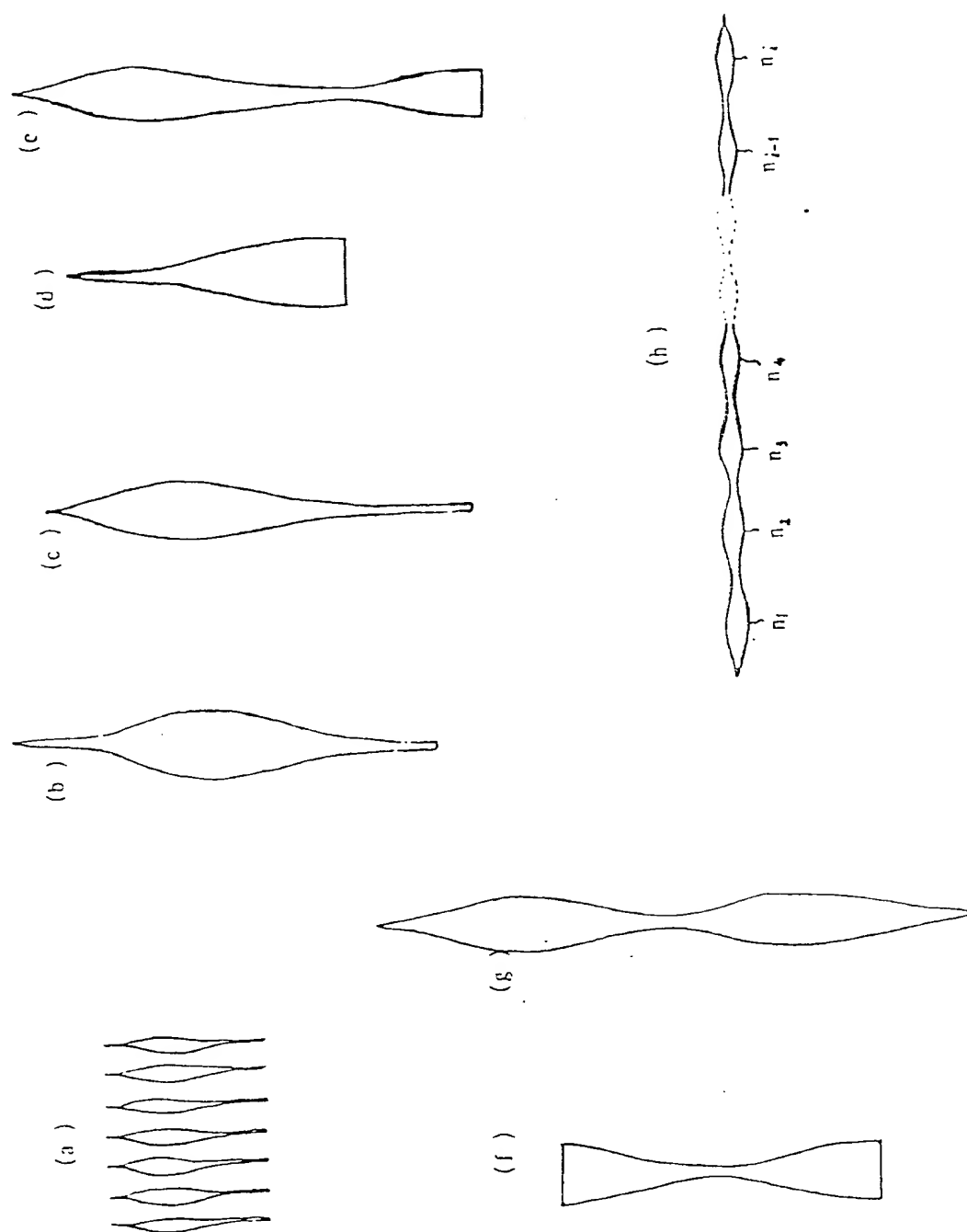
15        35. A method according to claim 31, wherein the drawing is carried out by a drawing ratio on which condition the thick-and-thin ratio of the drawn filament is always greater than that of the undrawn filament for the drawing.

20        36. A method according to claim 31, wherein the setting in the fifth step is performed for more than 0.01 second under a temperature between the glass transition temperature and the melting point of the polymer concerned.



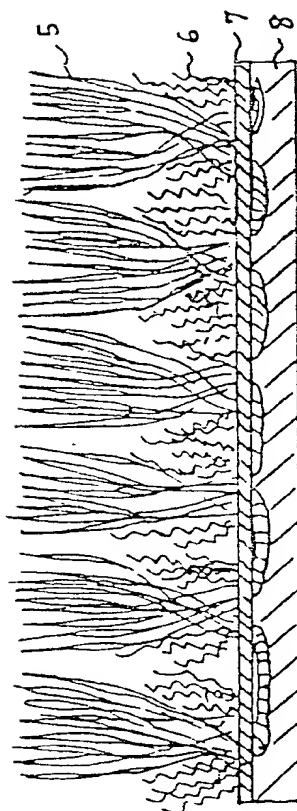
2/4

Figure 3



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Figure 4



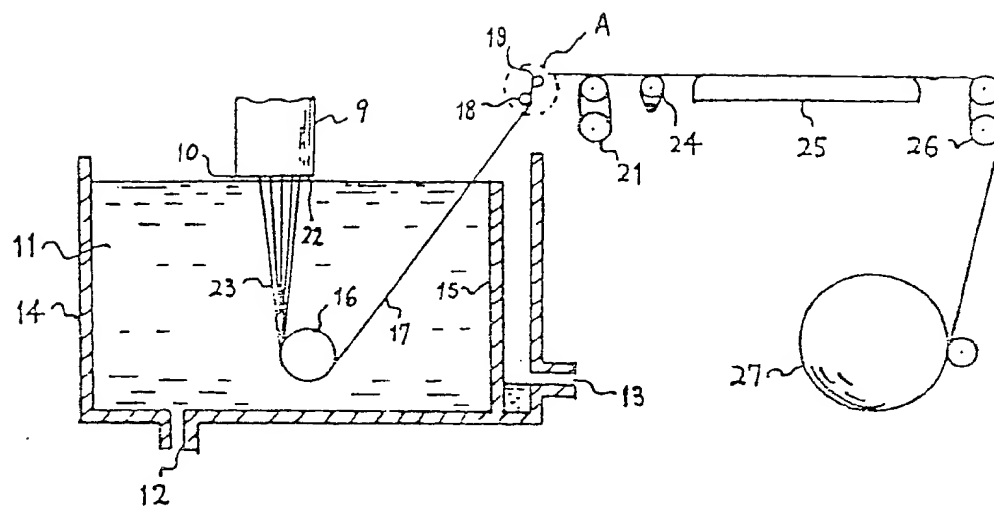


Figure 5

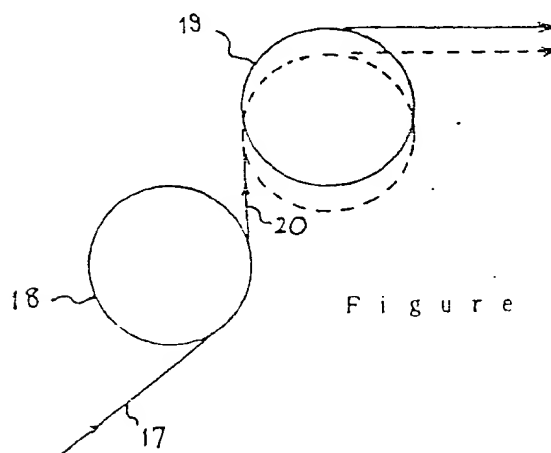


Figure 6



European Patent  
Office

# EUROPEAN SEARCH REPORT

0030566

Application number

EP 79 10 4797

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 1)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>GB - A - 1 141 394</u> (TOYORAYON) * Claims 1,2; page 2, lines 118-120 *	1,2,11 15,17	D 01 D 5/20 D 03 D 27/00 D 04 B 1/04 D 05 C 17/02
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D	<u>US - A - 2 418 492</u> (DU PONT) * Claim 1 *	31	
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A	<u>US - A - 3 827 932</u> (MITSUBISHI RAYON) * Claims 1,2; column 3, lines 63-71; column 4, lines 3-6, 13-22; column 6, lines 52-55 *	1,2,5, 15,21, 31	TECHNICAL FIELDS SEARCHED (Int. Cl. 1)  D 01 D 5/20
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A	<u>US - A - 2 745 136</u> (DELAMARE) * Claim 1 *	31,33	
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A	<u>FR - A - 2 202 959</u> (KANEKAFUCHI) * Claims 1-4; page 6, lines 9-14 *	1,5, 18,22- 24	
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			CATEGORY OF CITED DOCUMENTS
			X. particularly relevant A. technological background O. non-written disclosure P. intermediate document T. theory or principle underlying the invention E. conflicting application D. document cited in the application L. citation for other reasons
			& member of the same patent family, corresponding document
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
The Hague	19-06-1980	MATTHE	